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REGRESSION COEFFICIENTS USED TO ADJUST BOBWHITE QUAIL WHISTLE COUNT DATA[1]

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Abstract: During a 3-year study of factors effecting changes in the number of bobwhite quail (*Colinus virginianus*) whistles heard by investigators, the number of calls heard during 2,684 separate 5-min whistling periods were analyzed with respect to several time and weather variables by the multiple linear regression method. Time of year, time of day, wind velocity, temperature, and relative humidity were significantly correlated to the number of quail whistles heard. Correction formulae were developed incorporating regression coefficients, time and meteorological standards. The importance of each variable is discussed.

Game bird sounds have been studied for several species, and variables which affect this behavior have been identified by several workers. Kozicky et al. (1954:264) found wind velocity, temperature, and rain important variables to consider when conducting peent counts, while Pitelka (1943:98) reported normal day-to-day variations in temperature did not appear to influence the woodcock's (*Philohela minor*) rate of calling. Kimball (1949:112) found wind velocity influenced pheasant (*Phasianus colchicus*) crowing counts but no temperature-related effects were detected by Kozicky (1952:432). Environmental temperature has been found to influence results of bobwhite quail whistle counts (Bennitt

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1951:21, Elder 1956:645). Both time of day and time of year influence rates of vocalizations among most game birds (Kimball 1949, Taber 1949, Nelson et al. 1962, Kozicky et al. 1956).

Norton et al. (1961:403) reviewed several papers and presented new data indicating that quail whistle indices were poor predictors of fall population size or hunter success. Their data were collected by listening at route stations for several minutes. Counts were generally begun from 25–30 min after sunrise and continued throughout the next 1 or 2 hours. In some cases, counts were adjusted for the effects of temperature or taken only when temperatures were within a specific range of 60–80 F. They indicated that considerable refinement was necessary before indices based on quail whistle counts could be useful to wildlife managers.

The purpose of our study was to identify meteorological and time factors which influence the number of bobwhite quail calls recorded, and estimate their effects. Whistling behavior of quail can, perhaps, be better understood and a refinement in the construction of quail call indices can be achieved once these factors and their effects are indicated.

THE STUDY AREA

This study was conducted in the northwestern region of the Flint Hills, Riley County, Kansas. Topography consists of rolling prairie land broken by the valleys of Mill, Baldwin, and Wildcat Creek drainages.

The study area is principally true prairie with some timber along water courses. Herbaceous upland plant associations are dominated by grasses, including bluestem (*Andropogon* spp.),[4] grama (*Bouteloua* spp.), switchgrass (*Panicum virgatum*), and Indian grass (*Sorghastrum nutans*) mixed with many forbs (Fish 1953). Thickets of American plum (*Prunus americana*), snowberry (*Symphoricarpos occidentalis*), and smooth sumac (*Rhus glabra*) extend into the grassland in many areas, and aromatic sumac (*R. aromatica*) and red cedar (*Juniperus virginiana*) are common in some pastures.

Both lowland and upland woods are represented; the lowland type found only along water courses is typified principally by cottonwoods (*Populus sargentii*) and willows (*Salix* spp.). Bank-woods of oak–hickory (*Quercus* spp. and *Carya* spp.) and hedges of osage orange (*Maclura pomifera*) are present in some areas.

Various croplands are interspersed between the upland prairie and the lowland deciduous forests, primarily corn, grain sorghum, common wheat, and alfalfa.

MATERIALS AND METHODS

Quail whistle counts were taken at a permanent listening station and along two 10-mile listening routes during each spring and summer of 1963, 1964, and 1965. Variables measured were: time of day (X_1), day of year (X_2), wind velocity (X_3), light intensity (X_4), barometric pressure (X_5), temperature (X_6), and relative humidity (X_7). The most important variable influencing the number of whistles recorded, male quail population, was partially controlled within each year by use of the permanent station and the same stops along the routes.

The permanent listening station was equipped with a Short and Mason hydrothermograph and standard rain gauge. Wind velocity was measured with a Deuta-Werke hand-held anemometer, light intensity with a Gossen Tri-Lux footcandle meter, and barometric pressure with a Taylor meteoro-

[4] Common and scientific names of vegetation after Anderson (1961).

logical barometer. The station was established 15 April, 1963.

Whistle data were taken once each week for the 3 years within the following time intervals: 15 April–31 July, 1963; 27 March–31 August, 1964; 1 April–30 June, 1965. Two investigators listened for 5-min intervals at 15-min intervals beginning ½ hour before official sunrise until 2½ hours after sunrise. During each listening period, the number of whistles heard per min was tallied.

On 18 March, 1963, two 10-mile listening routes were established on secondary roads with a listening post located every ½ mile for a total of 40 listening stations, 20 on each route. From 25 March–31 July, 1963, 27 March–31 August, 1964, and 1 April–30 June, 1965, each route was traversed by two investigators once each week beginning ½ hour before official sunrise. The direction of travel on each route was reversed each week. At each listening post one observer listened for 5 min and tallied quail whistles (full "bob-white" calls) heard for each minute, the second observer collected meteorological data with appropriate instruments; with the exception of a Bendix Frieze Psycron for temperature and relative humidity, the equipment was the same as that used at the permanent station. Time of day was recorded at the beginning of each listening period. After each 5-min period, the investigators drove to the next station and repeated the above procedure. The total time to complete each route was approximately 3 hours. Unusual weather conditions or other phenomena that could affect calling or audibility were entered in a daily field notebook.

Total calls per 5-min periods from both the permanent station and the routes were used in the analysis. The route data were analyzed by separate stations for each year, by pooling the stations on each route for each year, and by pooling years. Data from all sources were pooled and evaluated for evidence of the importance of single variables. A linear relationship between whistle counts and any particular variable was identified using the usual statistical test for simple correlation. When multiple regression analysis was done, the value of a variable in the prediction of whistle counts was determined by evaluating the reduction in the remaining unexplained sum of squares after having fit all preceding variables. No transformation of the predicted variable was made.

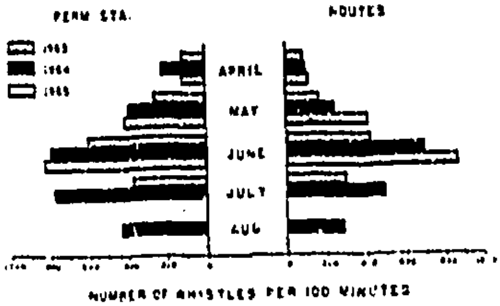

Fig. 1. Frequency distribution of 51,071 quail whistles heard along two 10 mile routes and one permanent station during 1963, 1964, and 1965.

All X variables were correlated with number of quail whistles (Y_1). The X variables were then stratified and the data analyzed in three parts:

1. time factors (X_1 and X_2) using the equation $Y = a + \sum_{i=1}^{2} b_iX_i$,

2. meteorological factors (X_3 through X_7) using the equation $Y = a + \sum_{i=3}^{7} b_iX_i$,

3. all variables using the equation $Y = a + \sum_{i=1}^{7} b_iX_i$. In several instances, a quadratic component of X_1 and X_2 was included

but deleted for reasons of brevity and little improvement in prediction.

RESULTS

In 1963, whistling activity peaked on 17, 19, and 28 June; in 1964 on 29, 24 June, and 17 July; *in 1965 on 15, 17, and 19 June for* route 1 and 2 and the permanent station, respectively (Fig. 1). In most cases, after these peaks, a gradual leveling off was witnessed. (A small secondary peak was recorded during late July and early August in both 1963 and 1964.)

Variation in Number of Calls per Listening Period Attributable to Variables Tested

To account for the effect of the calling peak on linear regression analyses by day of year, pooled route and permanent station call and meteorological data were separated *into two parts: (1) pre-peak period and (2)* post-peak period. All R^2 values for pre-peak analyses proved to be significant ($P < 0.01$) for all treatments of data, that is, time, meteorological, and total factors. For post-peak analyses, all R^2 values were significant ($P < 0.01$) except for time factors of 1963 route data.

Using time factors alone (X_1 and X_2), *the R^2 values or fraction of variance of quail* whistles (Y) attributable to the time factors were significant ($P < 0.05$) for 93 and for 66 ($P < 0.01$) of 120 separate station analyses. Using meteorological factors alone (X_3 *through* X_7), the R^2 values were significant ($P < 0.05$) for 81 and for 38 ($P < 0.01$) of 120 separate station analyses. Using total variables analyzed (X_1 through X_7), the R^2 values were *significant* ($P < 0.05$) for 112 and for 76 ($P < 0.01$) of 120 separate station analyses. The highest and lowest R^2 values were 0.87 and 0.03, 0.90 and 0.10, 0.99 and 0.24 for time, meteorological, and total factors, respectively.

Variables that Affect Calling

The results indicated day of year, time of day, wind velocity, temperature, and relative humidity as the most important factors evaluated as a prediction group af*fecting the number of quail whistles heard* during the course of this 3-year study. Light intensity and barometric pressure had little influence on the number of quail whistles heard.

Regular whistling by bobwhites began in early April and reached a peak in mid-June to mid-July. Bennitt (1951:13), Kabat and Thompson (1963:115), and Hartowicz (1964: 1–2) *also reported* peaks of whistling activity from mid-June to mid-July. Bennitt (1951) noted a continuance of quail whistles at the level of the peak after the peak was reached. However, data of Kabat and Thompson (1963:111) and that collected during this study showed a definite decrease of whistling activity following the peak whistling period.

According to Speake and Haugen (1960: 91), bobwhite quail whistling activity fluctuates with nesting activity and sharp declines in calling follow peaks of hatching. Hartowicz (1964:1–2) reported the statewide peak of quail hatching in Kansas as mid- and late-June of 1963 and 1964, respectively. Those hatching peaks correspond favorably with peaks of calling recorded for our routes during 1963 and 1964. The *permanent station data for* 1963 and 1964 do not correspond to those hatching peaks, but the peak in 1964 was about 2 weeks later than that of 1963 as was the peak of hatching. The relatively small area *sampled by the permanent station may par*tially explain the difference in peaks of hatching and calling.

The whistling peak in 1963 was short and sharply defined, while in 1964, the peak *was longer and less distinct.* The hatching

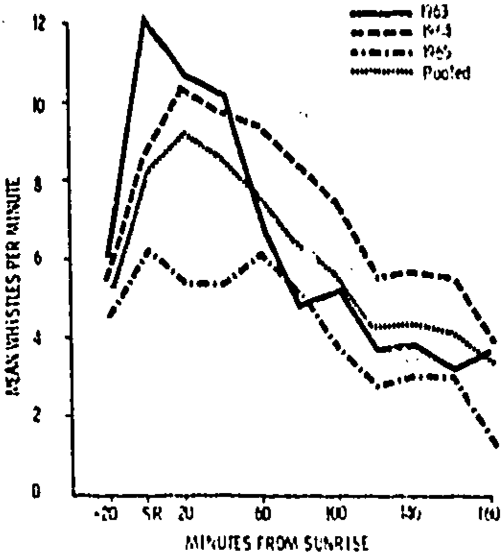

Fig. 2. Time distribution of 4,146, 2,276, and 2,840 quail whistles recorded during 1963, 1964, and 1965, respectively. Data for the three years were pooled to plot the mean.

curve reported by Hartowicz (1964:1–2) for 1963 in Kansas was likewise sharper and more distinct than the 1964 hatching curve. Therefore, a sharp peak in whistling activity may denote a sharp hatching peak and vice versa.

Average daily whistling activity increased from before sunrise to a peak about 20 min after sunrise and then declined. In 1963, twice as many calls were heard at sunrise as 1 hour after sunrise (Fig. 2). In 1964, a 25 percent decline in calling activity was noted between sunrise and 1 hour after. In 1965 calling activity from sunrise to 1 hour after did not decrease substantially probably because of cloudier and windier weather encountered during the 1965 study period. Taber (1949:171) noted pheasant crow counts before sunrise could be compared with counts taken after sunrise only on cloudy, windy days. The average activity of calling for the 3 years declined 50 percent between sunrise and 1 hour after sunrise (Fig. 2). Bennitt (1951:15) and Elder (1956:643) reported no substantial decrease in calling activity in the hour following sunrise.

Except during heavy rain when quail ceased whistling entirely, wind was the the most important meteorological factor influencing the number of whistles heard. As wind velocity increased, number of calls heard decreased. Two factors, fewer whistles and reduced audibility radius, could be causes. Probably a combination of the two accounted for hearing fewer whistles.

Route data generally showed poor correlations between wind velocity and quail whistles except for stations exposed to the wind. Wind measurements taken at stations sheltered by vegetation and topography were not representative of actual wind velocities of the general area. The permanent station was exposed to the wind. Representative velocity measurements there closely correlated with number of calls heard.

Each mile/hour increase in wind velocity affected whistling more after the seasonal peak of whistling than before. Bennitt (1951:19) reported no correlation between quail calls and wind velocity. Elder (1956: 649) found no correlation between quail whistles and wind velocity but noted that a correlation may have been found had wind velocities been higher. (Elder recorded wind velocities greater than 8 mph only 2 of 53 mornings.)

After the seasonal whistling peak, a negative correlation between calls heard and temperature was noted. Before the peak was reached, however, temperature correlations were sporadic, being both positive and negative. The route data usually showed negative correlations and the permanent station positive. Generally, positive correlations were associated with pre-peak call data while negative correlations appeared in post-peak analyses. Bennitt (1951:21) and Elder (1956:648–649) reported correlations between temperature and total calls heard. Their studies were conducted during the post-peak period and their correlations were negative.

A negative correlation of calls with relative humidity was noted both before and after the seasonal whistling peak. Bennitt (1951:21) and Elder (1956:649) reported no relationship between relative humidity and calling activity.

Both temperature and relative humidity caused a change in whistles emitted but not in the audibility radius. Attenuation of sound at the temperatures and relative humidities experienced during this study was not great enough to be detected nor to cause any appreciable change in the radius of audibility of quail whistles (Rudnick 1957:3–3, Beranek 1960:191).

After the seasonal whistling peak, a negative correlation of whistles with barometric pressure was detected. The correlation was considered spurious and tentatively attributed to topography. During a single *morning* when barometric pressure was stable, more whistles were tallied at higher elevations than low elevations due to a larger audibility radius from the higher stations and a larger number of birds in the upland pastures. Permanent station and separate station analyses, where altitude was constant, showed little correlation between calls and barometric pressure.

Of the factors tested, light intensity was least correlated with quail whistles. Light intensity ranged widely, from less than 0.1 footcandle to 5,000 footcandles during a single morning. Light measures may have been misleading since quail could be whistling in the open when light measurements were being made in the shade and vice versa.

Application

A refinement in call indices for quail could be achieved by adjusting route counts for variables found in this study to affect calling behavior.

An example of such an adjustment might be to select at random a few permanent stations in the area to be sampled using routes. At each station data could be collected to estimate an adjustment equation of the form Y (counts per listening period) $= a + \sum_{i=1}^{k} b_i X_i$, where the b_i are partial regression coefficients and the X_i are affecting variables. Then each observation taken at random sites on the routes would include not only number of calls per period but measurements on the X_i as well. Then the adjusted number of calls could be calculated:

$$Y_{adj} = Y_{obs} - \sum_{i=1}^{k} b_i \left(X_{obs.} - X_{std.} \right)$$

Here the subscript *obs.* identifies an observed number and *std.* identifies the value at which that variable is to be standardized. The b_i are those estimated from the permanent station analysis which would be free of the effects of X variables and reflect population size with less variation.

It is shown that for the study area discussed earlier in this paper, the reduction in variation, over and above that due to population size, achieved by accounting for differences in environmental and time variables is important. The amount of the reduction will be R^2 times the variance among raw call counts. In areas where R^2 for the adjustment equation is large an appreciable refinement will be realized. Such a refinement, incorporated with a good sampling plan indicated that quail call indices should be reconsidered as a management aid, especially as an index to spring breeding populations and possibly hatching peaks.

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